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Office of Science

Experiences from the Large Hadron Collider

OFES Budget Planning Meeting

Jim Yeck

March 18, 2003

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OUTLINE

- Overview of the LHC & Experiments
- CERN Experience
- U.S. LHC Construction Project
  - Management Approach
  - Lessons Learned
- Summary

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WHAT IS THE LHC?

- Particle physics facility in construction at CERN (14TeV & 10^{34}cm-2s-1)
- A few thousand superconducting magnets (8.3T @1.8K)
- Civil construction work (~100m underground)
- Four large experiments (ATLAS, CMS, ALICE, and LHC-B)

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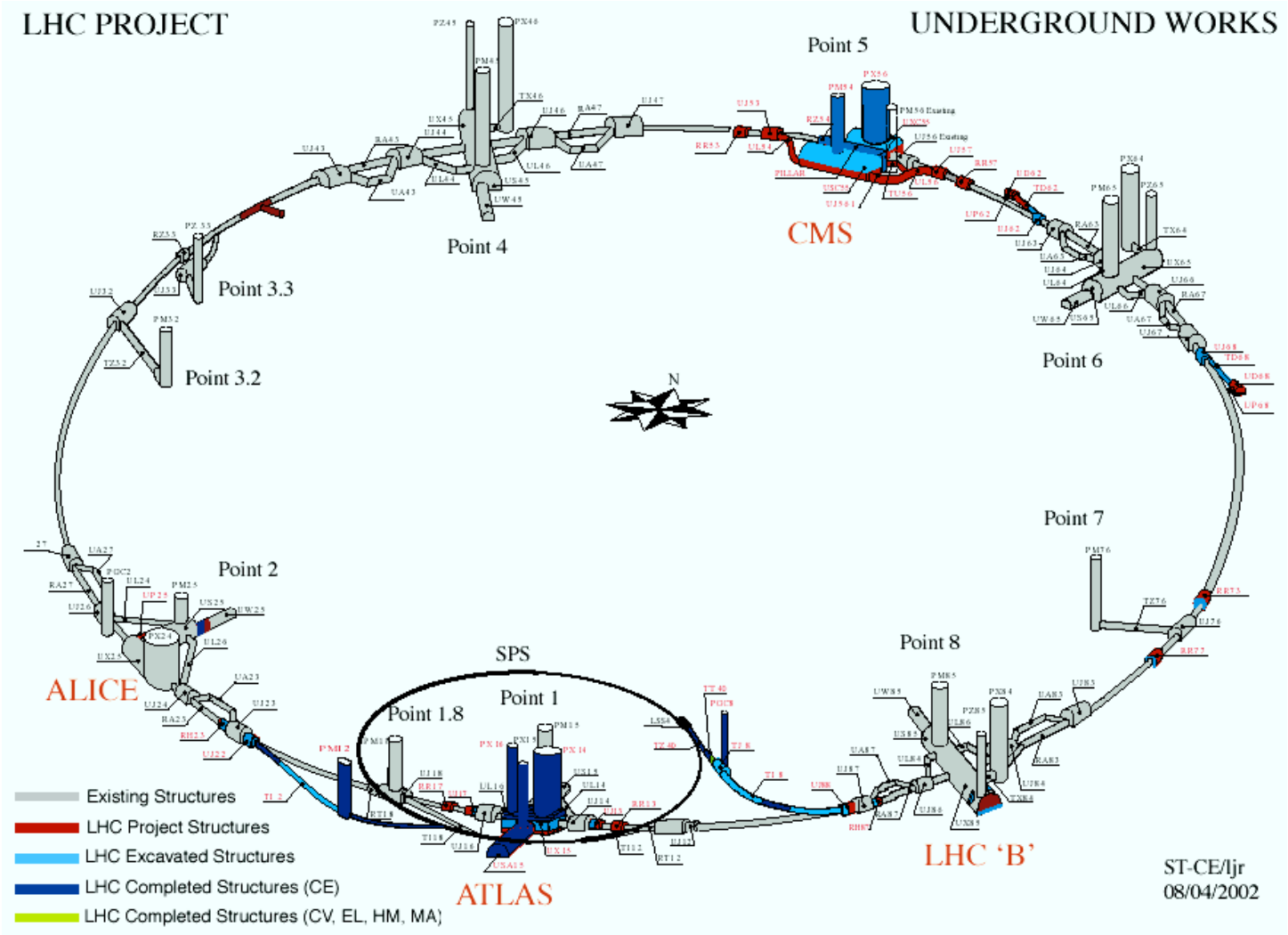
LHC MACHINE



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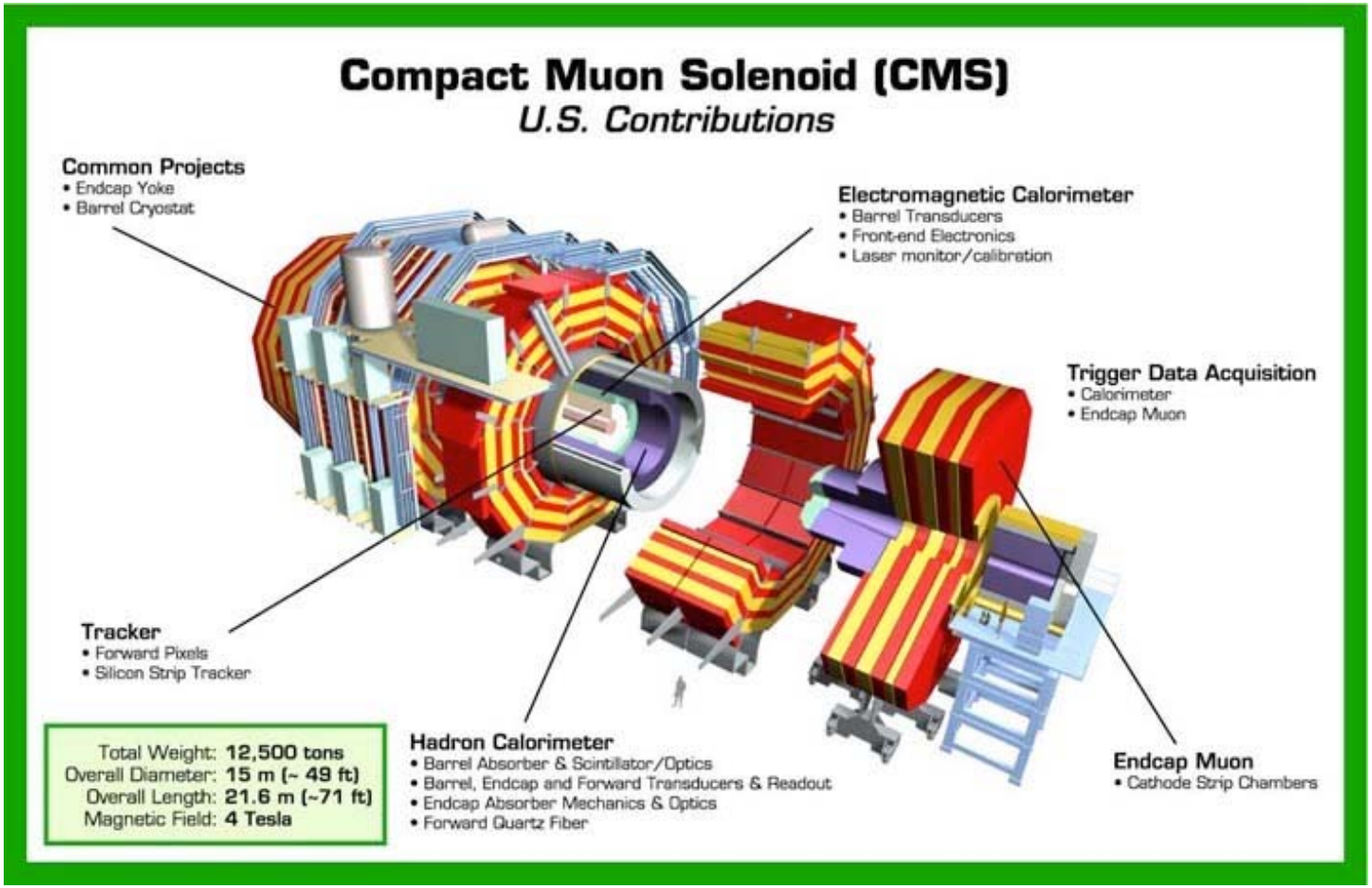
CMS EXPERIMENT



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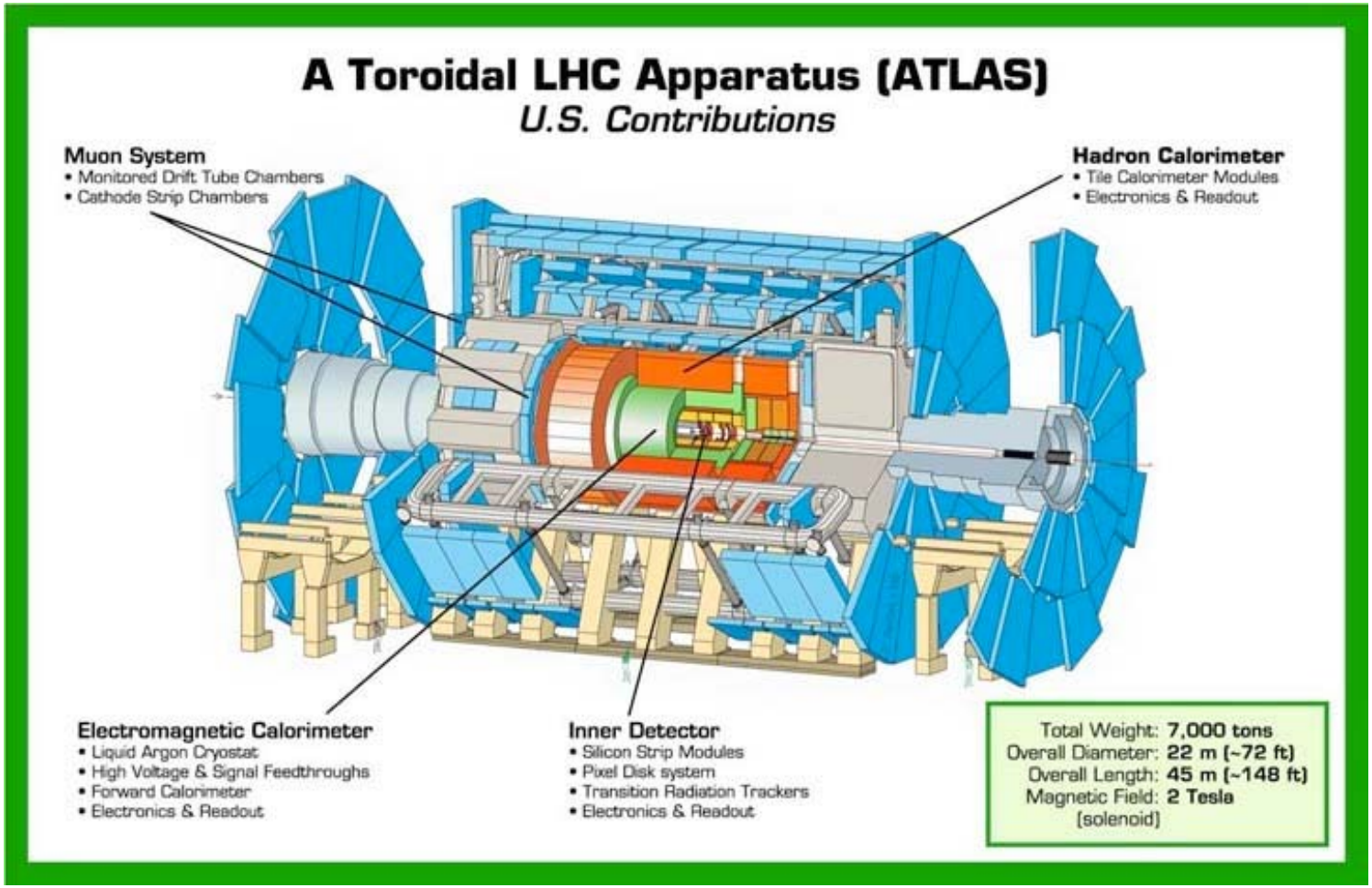
ATLAS EXEPERIMENT



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CHALLENGES

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news

CERN puts research on hold to build collider

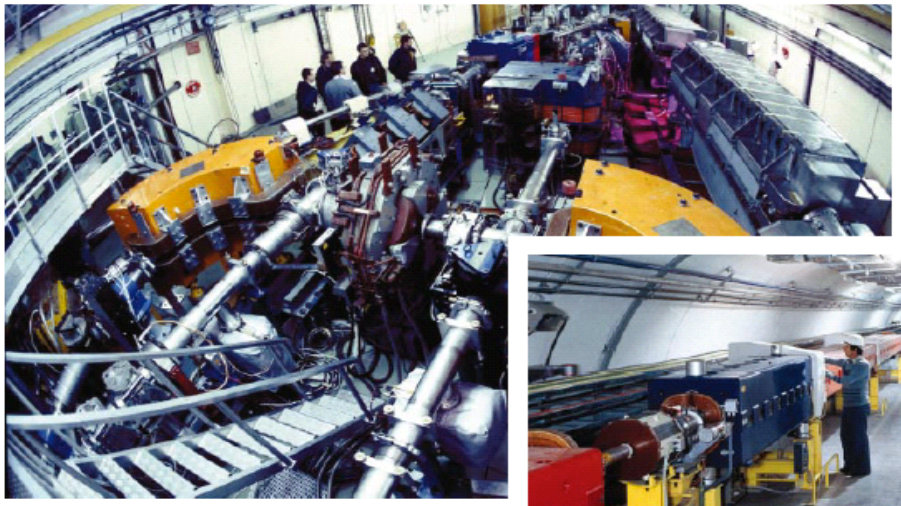
Alison Abbott, Munich

CERN, the European particle-physics laboratory in Geneva, Switzerland, is to shelve most of its medium-term research plans in a bid to ensure the completion of its main project — the construction of the Large Hadron Collider (LHC).

Under a retrenchment plan agreed on 21 June between the laboratory's management and its governing council, physicists at CERN will generate practically no fresh experimental data during 2005. Some researchers have already expressed fears about the impact of this data drought on the laboratory.

Cost overruns totalling SFr850 million (US$570 million) on the LHC's SFr2.6-billion construction cost were exposed last autumn (see *Nature* 413, 557; 2001). Council members, whose governments foot CERN's bill, were angry that its director, Luciano Maiani, had known about the problem for months but had not informed them.

In September, Maiani set up internal task forces to consider improvements in CERN's management and to find ways of saving money to pay for completion of the LHC. CERN's council, meanwhile, established an external review committee, chaired by Robert Aymar, director of ITER, the international project to build an experimental magnetic fusion reactor.



Cost cutting: the Proton Synchrotron (above) and Super Proton Synchrotron will be shut down for all of 2005.

Both processes reached similar conclusions, and CERN's council has now accepted Maiani's plan to implement these by streamlining the laboratory's management, winding down small research projects and adjusting the LHC construction plan.

The LHC, which physicists hope will find the Higgs boson, will not now come on line until 2007, two years later than originally planned. Loans have been arranged to extend the period of payment for the LHC until 2009.

Work not related to the LHC is being cut back to concentrate CERN's resources on the collider. Running time at the Proton Syn-

Ocean carbon study to quit Hawaii

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CERN EXTERNAL REVIEW

- External Committee (R. Aymar) recommended changes and efficiency improvements:
  - organization, project structure, and manpower planning
  - contingency, accounting, earned value
- CERN program reduced and debt repayment extended.
- LHC grows from ~50% to ~75% of CERN program.
- Start-up of the facilities revised from 2005 to 2007.

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US-CERN RELATIONSHIP

U.S./CERN – International Agreement defines U.S. contribution to construction as $531 million. DOE - $450M (machine = $200M) and NSF - $81M.

Our contribution to construction (including installation) is capped.

Construction Deliverables:

U.S. ATLAS: ATLAS Memorandum of Understanding

U.S. CMS: CMS Memorandum of Understanding

U.S. LHC Machine: U.S./CERN Implementing Arrangement

Significant changes approved by DOE/NSF.

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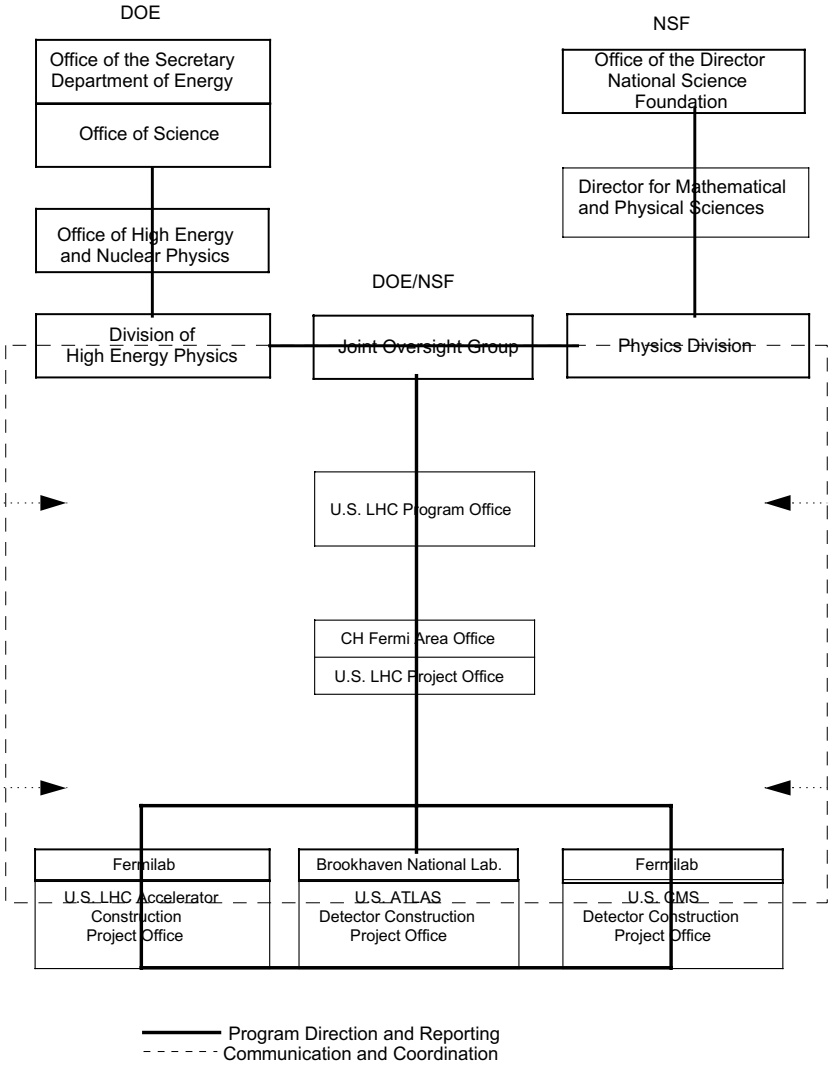
USLHC ORGANIZATION

U.S. LHC Construction Project Organization



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USLHC PROJECTS

U.S. LHC Accelerator - $200 million (DOE funding only)

- Fermilab/Brookhaven National Laboratory/Lawerence Berkeley National Laboratory Collaboration - $110 million
- CERN Direct Purchase from U.S. Industry - $90 million

U.S. ATLAS Detector Construction – $163.75 million

U.S. CMS Detector Construction - $167.25 million

"Base" program support for physicists and infrastructure at labs and universities.

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AGENCY OVERSIGHT

DOE/NSF Joint Agency Approach

- DOE/NSF MOU addresses joint responsibility for Construction and Research Program.
- DOE/NSF Joint Oversight Group (U.S. program coordination)
- U.S. LHC Construction Project Execution Plan & detailed Management Plans
- Project Reporting and Reviews
  - Extensive formal reporting, quarterly meetings and site visits
  - Regular "Lehman" reviews

Host/Lead Laboratory Role and Advisory Committees

▪ U.S. ATLAS	BNL	A.D. w/ Project Advisory Panel
▪ U.S. CMS	FNAL	D.D. w/ Proj. Management Group
▪ U.S. LHC Accelerator	FNAL	A.D. w/ Project Advisory Group

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PROJECT BASELINES

Baseline Characteristics (1998)

- Peer Reviewed ("Lehman" Reviews)
- Cost Contingency
  - U.S. LHC Accelerator at ~20%
  - U.S. CMS and U.S. ATLAS at ~40%
- Schedules
  - Construction activities scheduled to end in 2004
  - Project completion date set to match LHC schedule (FY05)
- Technical
  - Detailed list of deliverables
  - Scope reduced from original plans to create adequate contingency
- Management
  - Collaboration/Project relationships established

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PROJECT HISTORY

Changes

- U.S. LHC Accelerator
  - Earned contingency early (>20%) allowed scope additions
  - Now struggling to hold contingency at ~20% of ETC
  - CERN direct purchases from U.S. industry had slow start
- U.S. CMS & U.S. ATLAS
  - Earned contingency early on material contracts
  - Some scope added but holding contingency at 40% of ETC
  - Priorities on scope additions established with international collaboration leadership
  - Some schedule delays driven by slow production starts and external factors, e.g., delivery of parts from collaborators

Bottom Line

- U.S. projects/collaborations are fulfilling their commitments and completing additional scope within the total project cost

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COMPLETION STRATEGY

Our strategy is to complete U.S. deliverables on cost and schedule:

- no change to the construction commitment of $531 million
- cost effective use of funding supporting maximum deliverables
- 97% percent of our work will be completed by end of 2005

Implications of this strategy:

- Most deliveries occur well before the physics program begins requiring a pre-operations period

Construction Endgame:

- ~ 3% of U.S. construction activities are tied to the LHC start-up schedule, e.g., final installation and commodity computing purchases will fall beyond the original completion date

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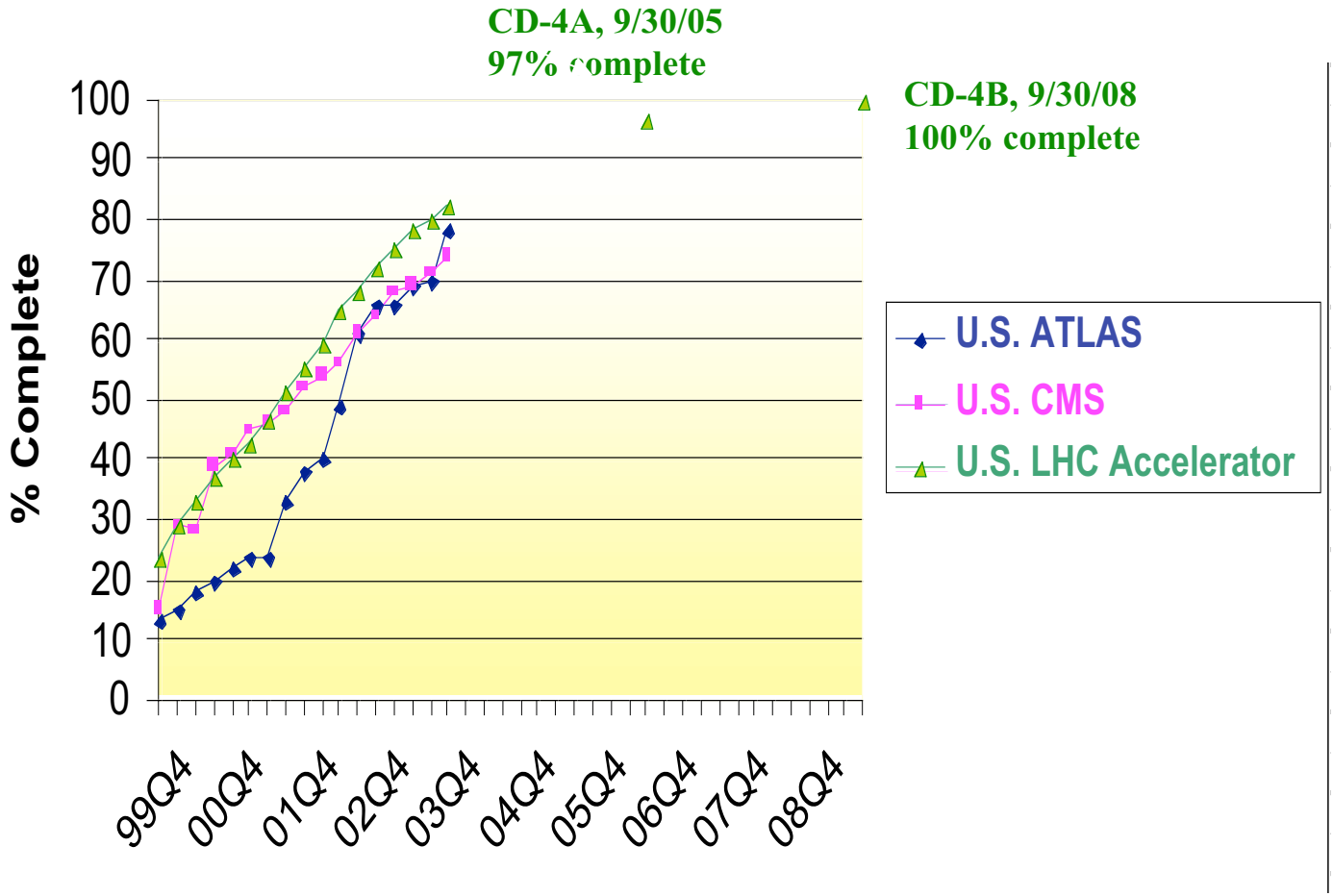
PROJECT COMPLETION



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SUCCESS/CHALLENGES

DOE and NSF coordination

- DOE/NSF Memorandum of Understanding
- Active joint agency coordination
- Bi-weekly teleconference coordination meetings

Advance planning for the LHC research program

- DOE/NSF MOU modified to include the research program to enable joint planning
- Assigned roles for host labs and U.S. collaboration leadership

SUCCESS/CHALLENGES

Reviews & Status Meetings

- Peer reviews throughout life of the project
  - Goal of no surprises and full transparency
  - Coordinated w/ internal reviews
- Quarterly Status Meetings
  - Integrated Project Team coordination
  - Issue resolution and follow-up

Reporting

- Formal – more than necessary; Informal - constant
- Some overlap between DOE and NSF

SUCCESS/CHALLENGES

Project Managers

- Appointed by host labs with concurrence of the DOE/NSF JOG and the U.S. collaborations
- Highly capable management team
- Successful managing to the U.S. project baselines and meeting the DOE and NSF project requirements
- Continuous challenge managing the interface with the international collaboration

U.S. Collaborators

- Working with the project management paradigm

SUCCESS/CHALLENGES

Funding

- Long term funding commitment for the full $531M
  - Nominally $70 M per year
  - Minor profile changes made after consensus, e.g., annual redistribution between projects
- Controlled by the project managers
  - NSF Cooperative Agreements, DOE Financial Plans and Grant Supplements, and subcontracts
  - Allocations to >70 U.S. collaborating institutions based on MOUs, annual SOWs, and resource loaded schedules controlled by the managers

SUCCESS/CHALLENGES

Interface Management

- Technical
  - Requires vigilance but still mixed results
  - U.S. would prefer a stronger CERN role
- Schedule
  - U.S. successful at keeping off the critical paths for the machine and experiments
- Cost
  - U.S. contingency strategy has helped but significant risk still remains

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SUCCESS/CHALLENGES

U.S. coherent approach essential (project vs institutes)

- CERN Relationship (e.g., Committee of Council)
- Experiments (Multi-lateral)
- Machine (Bi-lateral)
- U.S. collaborators work with U.S. and International Framework

U.S. LHC Accelerator three lab collaboration

- Struggle to operate as a single project

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LESSONS-LEARNED

Importance of Planning and Management Systems

- Baseline a project with realistic cost estimates and schedules and adequate contingency to address a substantial fraction of the risk (see GAO report on large science projects).

- Project leaders should implement management systems early, use these systems and revise as needed.

- Project leaders should actively pursue strategies to avoid, transfer, control and mitigate risk factors.

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LESSONS-LEARNED

Project Team

- Good working relationships are essential for large projects
- Decision-making authority should reside with the project manager with obligation to keep others informed
- Transparency in plans and actions engenders trust, confidence, and better quality
- Factorize a large project and align with competent managers
- Roles of team members should be understood and honored

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SUMMARY

- U.S. LHC is a large science project on track to successful completion in support of the LHC program.
- There are valuable lessons learned from U.S. LHC that are relevant and applicable to other projects.
- The U.S. LHC managers have received significant assistance and advice from the community and are willing to try to help others.